CALIFORNIA
ENERGY
COMMISSION

STRATEGIC PLAN TO REDUCE THE ENERGY IMPACT OF AIR CONDITIONERS

STAFF REPORT

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Abstract

As required by Assembly Bill 2021 (Levine, Chapter 734, Statutes of 2006), the California Energy Commission is providing a strategic plan designed to improve the energy efficiency and reduce the peak energy use of central air-conditioning systems in California. The plan was developed through a working group process to define a vision or new business model for the heating, ventilating and air-conditioning (HVAC) industry, investigate options to meet the vision, and recommend specific actions to be taken by public and private organizations to achieve the Legislature's goal of reduced peak energy use. The plan will grow and be refined as state energy agencies and stakeholders continue to address these issues.

The working group concluded that focusing merely on increasing or improving the rated efficiency of new cooling would not successfully result in reaching the goal of reduced peak energy use. This is because the widespread lack of quality control procedures during system installation can increase the actual HVAC system energy use by 20 to 30 percent, regardless of their rated efficiency. The lack of quality control is exacerbated by the failure of many contractors to pull building permits and verify quality when replacing air-conditioning systems.

The majority of the strategies presented in this plan focus on improving the customer's ability to verify that a quality installation has been achieved by introducing quality control procedures and a recognizable brand label to reinforce those quality control procedures. This report provides recommendations to increase the level and quality of training required of HVAC technicians ensuring that customer demand for quality can be met; reduce the cost of pulling permits and increase the probability that contractors will pull legally required permits; and complete quality work in compliance with building code and licensing requirements for HVAC installations.

Key words: HVAC systems, Title 24, central air-conditioning, vocational training, branding, Energy Star®, quality control, maintenance, HERS raters, strategic planning, utility energy efficiency programs, on-board diagnostics, building departments, enforcement and compliance, building standards, alternative cooling technologies, ductless cooling systems, radiant heating and cooling, duct testing

Executive Summary

Preface

Assembly Bill 2021 (Levine, Chapter 784, Statutes of 2006) directed the California Energy Commission to investigate options and develop a strategic plan to improve the energy efficiency of air-conditioning systems, and decrease their peak electricity demand. In response the Energy Commission convened a working group of professionals in the heating, ventilation, and air-conditioning (HVAC) industry to draft a strategic plan that would reduce California's peak-load growth while improving the business climate and level of quality workmanship in the HVAC industry. The Energy Commission noted that the best way to identify the needed changes and obtain willing industry players to help implement such changes was to have this group of industry professionals develop a plan that they could support. Staff of the Energy Commission and the California Public Utilities Commission sponsored this group so that ideas developed would provide consistent and complementary support to the mutual goals of this report to the Legislature and to the Big Bold Initiatives for Energy Efficiency. The plan will undergo further refinements as these efforts continue.

The Energy Commission commends this HVAC industry group for developing a comprehensive and ambitious plan. These thoughtful strategies will take both resources and a "drive" to carry out, however, the Energy Commission believes that these strategies offer a balanced and successful approach for gaining efficiency in California's HVAC systems.

The working group agreed that increases in the energy efficiency of air conditioners will not yield any significant increases in energy or peak savings unless known quality control problems in the HVAC industry are addressed. A discussion to ensure quality installation practices for all homeowners was used as a springboard for creating a vision of a preferable future and changes needed in the market to progress toward the vision. Subcommittees of the working group then developed specific strategies to achieve this vision. The vision and the strategies to achieve it are summarized below.

Vision

A revitalized HVAC industry will contribute to increased energy efficiency and reduced peak electricity use. California's consumers will recognize and demand quality installations and maintenance services of cooling and heating systems that result in lower peak energy use, better comfort, higher reliability, and better indoor air quality. This will lead to sustained profitability for the HVAC industry and trade allies as the business model changes from a commodity to a value-added service business.

Changes are needed in the structure and operation of the HVAC market to achieve this vision. Consumers must learn to expect and verify quality installation practices and maintenance of

their new central air conditioning systems. Contractors must routinely pull permits for HVAC system installations in existing homes and compete for customer jobs based on their reputation as a quality provider of installation and maintenance services that maximize comfort, system performance, and reliability. Building officials and Energy Commission compliance staff must work together to ensure consistent enforcement of the current building standard requirements so that conscientious contractors are not disadvantaged in the market for properly seeking a permit and certification of quality installation practices.

Changes are needed in the manufacturing and distributing of HVAC systems. Innovative system manufacturers must be encouraged to compete to deliver reliable, high comfort, space conditioning systems equipped with features that simultaneously minimize peak energy use and overall costs to the customer. Incentives should be provided to manufacturers who integrate smart diagnostic systems into original cooling system equipment to provide useful fault detection information to contractors and suggested actions to minimize usage to customers. Distributors of HVAC systems must work with the Energy Commission, trade organizations, and local building officials to design a new tracking database that ensures that all systems can be linked to a permit pulled for each customer address and verify quality installation practices.

Education is important. Utilities should work with contractor trade organizations to increase the quantity and quality of training and education programs for contractors and building officials. Contractors will need to agree on a universal definition of quality installation practices and support increased training and certification for all of their technicians, not just the owner of the HVAC firm. In addition, utilities should provide real-time feedback (education) to customers on the cost of operating appliances during peak periods as part of their deployment of advanced metering systems.

Strategies

The working group recommended 10 strategies to achieve these market changes. This report includes all of the strategies recommended without regard to securing the needed resources any state or local agency or private industry might require to carry out these strategies. Six of the strategies are targeted at improving the level of quality controls provided at the time of HVAC installation and the quality of the maintenance delivered over the life of the system.

- Create an industry recognized "quality" label (similar to Energy Star®) that can be used as proof of quality installation practices and high levels of HVAC technician competence.
- Increase customer demand for quality installations through a public education campaign that explains the consequences of a poor quality installation and encourages customers to ask for the quality label to ensure their system will perform and operate as advertised.

- Work with building officials to increase the level of code compliance (and quality installations) to create a new compliance tracking database designed to create a level playing field for HVAC contractors in the replacement market.
- Increase the number of trained technicians qualified to perform HVAC system installations that meet the Air Conditioning Contractors of America (ACCA) Quality Installation specifications and motivated to receive recognition for their verified quality work.
- Obtain a commitment from local governments, state agencies, utilities, and local building departments to devote more resources to educating customers, building energy inspections, and streamlining of the permitting process.
- Seek regulatory policy changes designed to encourage utilities to achieve larger scale market outcomes by estimating the energy savings achieved by the HVAC quality initiatives proposed here at the overall market level in addition to the program level.

The remaining four strategies were developed to achieve additional energy and peak savings from new and more peak efficient cooling systems installed over the next decade.

- Support commercialization of on-board and portable smart diagnostic and fault detection systems.
- Develop new energy efficiency indicators to rate the expected performance and energy use of space conditioning systems installed in California that more accurately predict system power demands in the hot and dry climates of the Southwest.
- Accelerate market penetration of new cooling equipment technologies by developing an incubator process that shortens the time between testing of an innovative new cooling concept to its demonstration and widespread market deployment.
- Create a market environment that encourages builders to experiment and use whole building designs and performance retrofitting to reduce peak demands and overall customer energy bills.

Finally, the California Energy Commission and California Public Utilities Commission and utilities should form an implementation task force that will be responsible for overseeing progress towards each of these HVAC strategies over the next three years.

CHAPTER 1:

Why a Focus on Revitalizing the HVAC Industry Is Critical to Minimizing Future Peak Electricity Demands

The California Public Utility Commission and Energy Commission focused on working with the HVAC industry because the rapid growth in the installation of central air-conditioning systems over the last three decades is the primary cause of the rapid growth in peak energy demand in California during that same time. There has been a dramatic increase in the proportion of new homes built with central air conditioning, from 25 percent in 1976 to more that 95 percent of new homes in 2007. This equipment saturation, coupled with a 55 percent increase in new home size (from 1,560 square feet to 2,390 square feet) over the same period has led to a six-fold increase in the electricity capacity needed to meet this load. Total peak demand attributed to residential air conditioning units has increased from 5 percent in 1976 to more than 24 percent in 2006.

Unfortunately, much of the anticipated and forecasted decreases in peak energy use associated with increases in the appliance efficiency standards for central air conditioners will not occur without meeting quality assurance procedures currently required in the building standards. Failure to ensure quality installations or maintenance of cooling systems result in a 20 to 30 percent increase in the peak electricity needed by such systems to provide customers with the cooling and comfort they demand on hot summer afternoons. [1] Improving the performance of the HVAC workforce by focusing on improving the quality of their workmanship is consistent with the Governor's and Legislature's emphasis on providing more vocational opportunities and reducing the growth in greenhouse gas emissions by increasing the value provided by the energy efficiency industry.

Higher quality installation practices suffered during the rapid growth in housing starts from 1990 to 2002 partly due to the difficulty in finding and maintaining trained HVAC technicians familiar with quality control requirements. Fewer available technicians and market pressures to build houses more quickly led to a race for the bottom in pricing for equipment installation jobs and, unfortunately, installation quality since there was no visible way for homeowners to ensure their systems had been properly installed. The size of HVAC technician labor force could not keep up with the rapid growth in demand for new central air conditioning systems in new construction and a burgeoning demand for retrofits in older homes not previously equipped

[1] Chris Neme, John Proctor, and Steve Nadel, *National Energy Savings Potential from Addressing HVAC Installation Problems* (Prepared for the U.S. EPA, February 1999.)

with central cooling systems. As a result, the quality of installations fell as fewer qualified technicians scrambled to install more systems in an overheated housing market.

Several parties called for an increase emphasis on quality control as part of the installation process, and the industry responded with new certification programs and efforts to draft procedures to verify that quality installations had taken place. Despite these private market efforts, the fraction of central air conditioning jobs meeting the quality installation specifications was quite low, and the Energy Commission decided to begin to require third-party testing. In late 2003, the Energy Commission adopted changes in the building standards that required third-party testing of airflow, refrigerant charge, proper sizing calculations, and potential leaks in the duct systems for central air conditioning systems under 10 tons. These changes went into effect in October 2005. The new code required third-party testing to ensure that airflow losses from ducting systems did not exceed 15 percent of airflow and that the refrigerant charge and airflow were within appropriate manufacturer specifications. Many builders chose not to use the third party verification system, and instead installed systems with higher efficiency ratings.

There are two primary methods to achieve potential peak and electricity savings from current and future air conditioner installations.

1. Increase the proportion of new and retrofit installations where high quality installation and maintenance practices are used and verified.

2. Decrease the peak affect of new air conditioning systems by accelerating the market introduction of more efficient direct expansion systems, evaporative cooling and other non-vapor condensing systems, or systems designed to use thermal storage concepts to shift the energy required from peak to off peak periods.

Preliminary estimates were developed by the working group of the peak savings potential from these two high level strategies. In Strategy 1, the pursuit of higher quality installation of commonly installed equipment could yield savings of up to 1,100 Megawatts (MW) by 2020. Strategy 2 would accelerate the market penetration of alternative cooling technologies with reduced peak usage (and assumes quality installation of these new technologies), achieving savings of up to 3,600 MW by 2020. (Appendix A contains the assumptions and calculations used to develop these savings estimates.)

CHAPTER 2:

A New Vision for the HVAC Industry

A revitalized HVAC industry can deliver increased energy efficiency and reduced peak usage of air-conditioning systems for all residential and small commercial customers. Quality installation and maintenance practices must be easily recognized by customers, and customers must understand the impact of high quality installations on customer comfort, system reliability, and indoor air quality. This industry will provide high quality installation and maintenance services in response to increased customer demands for quality and through more consistent enforcement of existing building standard requirements.

To achieve this vision, the industry and state level stakeholders must provide increased opportunities for training and certification for installation and maintenance technicians. As the industry matures, installation and maintenance of all space conditioning systems will be certified by third-party verifiers and/or credible remote verification technologies. It is important to increase the awareness for customers of how quality installation practices will have an effect on their home's comfort, health and safety, and energy bills. And, manufacturing and marketing innovation is needed to develop new cooling systems that are tailored to the needs of the local hot dry climate and the higher costs of meeting cooling demands during electricity peak demand periods.

These changes should lead to sustained profitability for HVAC trade allies as the business model for installing and maintaining heating and cooling systems changes from a commodity to a value-added service business. However, these changes cannot be achieved in one portion of the market alone. It will take complementary changes in the expectations of customers, building officials, local governments, and electric utilities.

Strategic Changes Needed to Achieve This Vision

The Energy Commission is pleased that the working group considered various strategies for achieving this vision. Those 10 strategies, in priority order as determined by the group, are:

1. *Increase the number of building permits pulled for HVAC replacement installations to increase the fraction of quality-controlled installations from 10 percent to 90 percent by 2020.* Building officials and Energy Commission compliance staff must work together to ensure consistent enforcement of the current building standard requirements so that conscientious contractors are not disadvantaged for pulling a permit and following high quality installation practices. The California Building Energy Efficiency Standards contain requirements for duct sealing when the HVAC equipment or duct systems are replaced. The standards require the refrigerant charge to be measured or require installation of a

thermostatic expansion valve. Field verification and diagnostic testing protocols must be used by installers and third-party verifiers to demonstrate compliance with the requirements. The standards also require altered or replaced HVAC duct systems to be installed, insulated, and sealed in compliance with Chapter 6 of the California Mechanical Code. All of this work (and associated costs) can be avoided if no permit is pulled; the many contractors who avoid the permit and most or all of the required work gain a market advantage over contractors who follow the law.

Distributors of HVAC systems should work with the Energy Commission and local building officials to design a new tracking database that ensures all systems that are sold to contractors can be linked to a permit pulled for each customer address and verify high quality installation practices.

The organizations that would be responsible for achieving this strategy are the Energy Commission, California Building Officials (CALBO), Institute of Heating and Air-Conditioning Industries (IHACI), Sheet Metal and Air Conditioning Contractors National Association (SMACNA), Air Conditioning Contractors of America (ACCA), local governments, distributors, and the utilities.

2. *Create an industry-recognized quality installation and maintenance label and launch a campaign to educate customers to demand quality installations.* The industry and the Energy Commission can build on the existing requirements in the Building Energy Efficiency Standards to achieve agreement upon a universal definition of quality installation and maintenance practices and a process to verify and then attach a quality label on all equipment that meets the specifications. The label could be developed in cooperation with Energy Star at the national level, or separately as a regional or statewide label.

   The organizations that would be responsible for achieving this strategy are the utilities, IHACI, the national Environmental Protection Agency (EPA), Energy Commission, ACCA, and SMACNA.

3. *Develop and/or sponsor quality installation and maintenance training for contractors, technicians, and sales agents to increase the fraction of technicians trained and certified from 10 percent now to 100 percent by 2020.* Contractors must support efforts to achieve more high quality installations by supporting increased training for their employees. Utilities should work with contractor trade organizations to increase the quantity and quality of training and education programs for contractors and for building officials.

   The organizations that would be responsible for achieving this strategy are IHACI, the Air-conditioning and Refrigeration Institute (ARI), ACCA, utilities via their various training centers, SMACNA, and CALBO.

4. *Create a market environment that encourages whole building design concepts to be incorporated into mainstream building developments.* The air conditioner does not work in isolation to

keep the house cool. The building itself plays a major role in assuring comfort for the occupant, and how well the building is insulated and sealed contribute to the occupant's comfort. Analyzing what changes are needed in the building (such as adding insulation, sealing gaps, installing radiant barriers) can help assure that the occupant achieves the expected comfort improvements.

The utilities, building performance contractors, and local governments would be responsible for achieving this strategy.

5. *Support commercialization of on-board and portable diagnostics for HVAC systems that identify faults, performance drops, and need for maintenance to prevent system failure.* Heating and cooling equipment performance will degrade over time and can experience problems for various reasons. Often the building occupant will not be aware that the system is not operating as it should. Encouraging the integration of diagnostic technologies in heating and air-conditioning systems, or adding a portable diagnostic technology, together with a light or signal that allows the homeowner to recognize that the system is under performing or failing, can facilitate needed maintenance or repair. Incentives could be provided to manufacturers who work to integrate smart diagnostic systems into the original cooling system equipment to provide useful fault detection information to contractors.

   The primary organizations that would be responsible for achieving this strategy are the equipment manufacturers, energy agencies, utilities, trade associations, and contractors.

6. *Develop a new technology incubator system that accelerates the market introduction of advanced cooling technologies.* Innovative system manufacturers should be encouraged to compete to deliver reliable, high-comfort, space-conditioning systems equipped with features that simultaneously minimize peak energy use and overall costs to the customer. The Energy Commission should help fund the Western Cooling Efficiency Center that has been established to develop and analyze efficient cooling technologies for western climates. In addition utilities should endeavor to provide real-time feedback to customers on the cost of operating appliances during peak periods as part of their deployment of advanced metering systems.

   The Energy Commission's Public Interest Energy Research (PIER) program, HVAC manufacturers, and utilities would be responsible for achieving this strategy.

7. *Seek regulatory policy changes designed to encourage utilities to achieve larger-scale market outcomes through increased emphasis on training, education, and compliance efforts.* If energy efficiency savings can be attributed properly to educational programs, utilities can receive credit for their programs from the Public Utilities Commission (CPUC). Linking energy savings to education may require a longer time horizon – as it takes time for newly trained technicians to translate the training into action in the field.

The utilities, CPUC, the Energy Commission and trade schools would be responsible for achieving this strategy.

8. *Sponsor research in on-board diagnostic systems by offering a "golden carrot" award for the first 100,000 HVAC units sold with on-board diagnostics.* Such awards have been successful in the past for other equipment such as refrigerators, stimulating innovation at a scale that can bring the new technology to market.

   The HVAC manufacturers, utilities and university research organizations would be responsible for achieving this strategy.

9. *Sponsor competitions to encourage builders to design and build homes with net zero peak demands.* Net-zero homes (and net-zero commercial buildings) is a concept gaining wide support as a critical element in climate change strategies by reducing the growth of energy use and peak electricity demand with the resulting emission reduction benefits. Design competitions could help spur builder interest in this concept and provide another avenue to recognize builders who step up to design and construct such buildings. A design competition could help identify or test which ideas are most likely to gain home buyer acceptance.

   The organizations that are logical sponsors include the utilities, building contractors and the solar industry.

10. *Encourage development of new cooling systems with technology and designs that target California-specific climate conditions.* Some of this research is already underway, and it should be continued and expanded.

    Research organizations, the Emerging Technology Coordinating Council, and the Energy Commission's PIER Program are the most logical responsible parties for achieving this strategy.

Assessment of Need for Potential Changes in Legislation

The Energy Commission believes that the proposed strategies will not require legislative changes or new authority but recognizes that the strategies will require increases in resources for the participating organizations.

Formation of a Statewide Working Group to Oversee Implementation of HVAC Strategies

The Energy Commission supports the working group recommendation that the state's energy agencies (Energy Commission and CPUC) and utilities form an implementation task force that will be responsible for overseeing progress toward each of these aggressive HVAC strategies over the next three years. The task force should be composed of members of the HVAC

industry, the energy agencies, and their utility partners and should be responsible for coordinating the efforts of key industry stakeholders. The task force should provide the energy agencies with periodic progress reports and recommendations for changes in policy based on experience in the field.

The Energy Commission sees value in this continued work and is pleased to note that the CPUC is using this working group/task force to help guide its work on the HVAC Big Bold Initiative for utility efficiency program planning.

The next chapters briefly describe ideas for stimulating the demand, and the supply, of high-quality HVAC practices in the California marketplace, as well as strategies to increase the efficiency of new space-conditioning systems. Thus, the strategies listed above are reorganized by those that stimulate demand, those that stimulate supply, and those that can increase the efficiency of equipment/systems. More detail can be found on the CPUC-sponsored website for the HVAC working group, located at http://www.californiaenergyefficiency.com

CHAPTER 3:

Stimulating the Demand for High-Quality Installation and Maintenance Practices for Central Air-Conditioning Systems

In the past, proposals to increase quality control focused on incremental improvement of the quality of supply-side delivery services via training and, later, through third-party verification of quality installations. However, these strategies cannot be successful in the long run unless the consumer learns to check that quality installation practices have been verified. Currently there is no easy way for customers to know if their HVAC system meets quality requirements, nor can customers easily recognize the increased energy use resulting from poor-quality installations or a lack of maintenance. The working group concluded, and the Energy Commission agrees, that the current one-sided focus on "forcing" more high-quality practices through Title 24 Building Energy Efficiency Standards and training will not be successful or sustainable unless there is a universal definition of what constitutes quality installation and maintenance practices and, more importantly, that customers would have an easy way to demand, expect, and recognize when quality installations and maintenance have occurred.

This chapter provides a set of recommendations to achieve the strategy of creating recognizable quality installation and maintenance brand or decal (Priority 2 in the list of strategies) and proposes milestones to track the progress of each strategy.

Develop a Consensus of the Definition of High-Quality Installation and Maintenance Practices Needed to Secure a Quality Label

It is important that the industry develop a consensus recommendation on the processes and measurements needed to verify high-quality installation practices. Actions to achieve this consensus include the following.

Recommended Actions

The Energy Commission and the electric and gas utilities operating programs to promote the installation of more efficient air-conditioning (and heating) systems should work together to define high-quality installation practices and reinforce their use by creating a label that could be attached to systems that meet specifications. A proposed definition for quality installation is: *An HVAC quality installation is one where the heating, cooling, and ventilation system has been installed in accordance with a nationally recognized standard and incorporates the original equipment manufacturer instructions, applicable building and energy codes, documentation of system commissioning elements, and customer education.*

The Air Conditioning Contractors of America (ACCA) recently developed a quality installation specification for air conditioning equipment that has become an American National Standards Institute (ANSI) standard. It is comprehensive, addressing all aspects of HVAC quality installation, including equipment, installation and ducts. Most of the 12 requirements in this specification are similar to the optional requirements for HVAC testing in California's Title 24 building energy efficiency codes. The Title 24 versions of the specifications require verification (typically a third party). The Energy Commission should consider making the ACCA or similar requirements mandatory for all HVAC installations. Quality installation and inspections that are optional under Title 24 are usually not performed because it is easier to gain the same Title 24 credit by installing HVAC equipment with a higher efficiency rating.

The working group also proposed that each of the 12 ACCA requirements must be completed and verified before a voluntary quality label can be attached to a residential or small commercial HVAC installation by a third-party rater. The utilities, Energy Commission staff, and industry trade representatives should decide together who should be responsible for verifying each of the quality specifications has been achieved and who provides a voluntary quality label to the customer. Candidates include building officials and third-party verification providers.

Stimulate a Stronger Customer Pull for High Quality Installation and Maintenance Practices

Currently customers do not demand verification of high quality installation practices because they assume it occurs already, nor do they have an easy way to verify that their HVAC system has been properly installed. Consumers are also not aware of the energy consequences of leaky ducts or improper refrigerant charge. The following recommendations are designed to make customers aware to ask for and verify quality installation practices have been followed.

Recommended Actions

The Energy Commission, CPUC, and the state's utilities should work together to develop and promote the use of a statewide quality installation and maintenance label for customers and contractors. A label could be affixed to the actual equipment after a third-party has certified a given installation has met the requirements. The federal Environmental Protection Agency is developing a quality installation certification for new central air conditioner installations and it may be possible for the state to test this new brand in California. The state must decide whether it would be better to develop a California-specific quality brand or partner with the federal Environmental Protection Agency to create a national high-quality brand.

The utilities and industry trade allies should launch a statewide customer education campaign to introduce and stimulate the customer demand for quality installations and maintenance and the associated label. The education campaign should include information on increases in energy and peak electricity use with improper installations that do not meet a quality standard.

Customers should be encouraged to use an industry or a trusted third-party source (for example, Energy Star, *Consumer Reports*, Edmunds, or similar group) that provide customer-focused materials on how to shop for contractors and ask the right questions before and after the installation process. The utilities and private industry should work together to develop and co-fund a consistent and well-coordinated customer education campaign.

The CPUC could consider providing differentiated electricity rates for those customers who sign up and possibly pay for periodic maintenance checks to slow degradation in cooling system performance and the associated increases in peak electricity demand. Such rates could provide a discount for building owners and/or consumers who purchase and maintain their HVAC systems in accordance with standards. The building owner would be required to obtain a third-party, functional performance evaluation every two years to qualify for the lower rate and submit it to the utility. This could create a market pull for quality/efficiency by reinforcing the importance of the well installed and maintained equipment.

Utility programs should provide incentives to customers who demand high quality or ask for the quality label after HVAC installations. Any incentive should be developed after conducting market research on customer buying behaviors related to contractor-provided home or building repairs. This research should characterize the behaviors of consumers, so that the most effective incentive (financial and/or non-financial) mechanism can be established. In consultation with the HVAC industry, the California Public Utilities Commission should design any such program to be as efficient as possible with as little administrative cost to the contractor, building owner, and the utility.

The web site, http://www.californiaenergyefficiency.com, sponsored by the CPUC, has suggested milestones developed by the working group for these recommendations.

CHAPTER 4:

Stimulating the Supply of Quality Installation Services in the Residential and Small Commercial HVAC Markets

This chapter describes the four strategies designed to increase the proportion of contractors who choose to supply high quality installation services and presents recommended actions to support each strategy.

Achieve Consistent Enforcement of the Existing Building Standards to Ensure Conscientious Contractors Are Not Penalized by Uneven Enforcement Practices

In Chapter 2, it was noted that there was a high level of non-compliance (more than 90 percent) with current building code requirements that require HVAC contracting firms to pull a permit for all replacements of HVAC systems[2]. In addition to this problem, a similar percentage of HVAC installers fail to perform quality control checks on key HVAC system performance parameters (such as refrigerant charge, airflow, and duct leakage) or have their work measured and verified by third-party raters as required by the building code in some climate zones. This lack of compliance with quality verification requirements and the fact that most building officials have no way to ensure enforcement of the current building requirements are a significant barrier to those contractors who would prefer to provide quality installation practices but are at a disadvantage because of the extremely competitive nature of this business. The strategy calling for actions to increase the rate of compliance with the quality installation requirements in the current code was identified as the top priority of the working group.

This section discusses the reasons why HVAC contractors choose not to obtain a permit for the installation of new HVAC equipment, identifies what can be done to address these reasons by creating a more level playing field, and then provides some recommendations for improving and modernizing the entire permitting process.

The working group identified four key reasons why the rate of pulling building permits for HVAC installations is so low:

- Many contractors perceive it takes too much time and money to pull a permit for an HVAC replacement, and some contractors are still unaware that a permit is required.

[2] M. Sami Khawaja, Ph.D., Allen Lee, Ph.D., Michelle Levy, Quantec, LLC, *Statewide Codes and Standards Market Adoption and Noncompliance Rates* (Prepared for Southern California Edison, May 10, 2007).

- Many contractors refuse to incur the costs of pulling a permit in a market where the majority of contractors will not pull a permit to gain a cost advantage in a market where the low-cost bid usually wins.
- Some building officials are unaware of the building requirements that require third-party verification of quality in HVAC installations and do not require a permit.
- Most building departments are never notified when an HVAC replacement job has been completed.

Recommended Actions

The Energy Commission and the California Building Officials (CALBO) should work together to make it easier for contractors to obtain a building permit. Both agencies must create a level playing field for contractors by ensuring that all new HVAC replacement installations have a permit and have received the necessary quality control checks. The Energy Commission could convene a California executive-level task force composed of local government officials, CALBO, Energy Commission representatives, manufacturers and equipment distributors, industry trade organizations, and utility executives to develop and propose a new HVAC permitting system that will make it easier to obtain a permit. The Commission and CALBO should encourage building departments to issue HVAC replacement permits on-line and/or allow permits to be issued at the supplier level. The Commission, CALBO, and/or local government representatives should investigate ways to reduce the costs of obtaining contractor business licenses for multiple jurisdictions. Contractors report that some business licenses are too costly. Some contractors avoid pulling permits because they will have to buy a business license for new jurisdictions. The working group developed a proposal to improve the existing building permitting process and is available on the working group's website at http://www.californiaenergyefficiency.com.

The Energy Commission should consider modifying the building energy efficiency code in 2011 by changing the current quality control requirements for HVAC systems from optional compliance methods to mandatory measures that would be required for all homes. The current requirements for ensuring a quality HVAC installation (testing for duct leakage, refrigerant charge, and airflow across the coil) is often traded for higher efficiency measures for all new buildings. Building officials and energy analysts recommend that these quality control procedures be made mandatory for all HVAC installations, since without these checks energy and peak electricity use of the cooling systems can increase by 30 to 50 percent above the level of expected usage from a given system.

It is important to enforce the penalties for contractors who choose not pull permits for the replacement and installation of space-cooling systems in California or those who operate without the appropriate license. Energy Commission staff should expand their work with building officials, and the Contractor State Licensing Board; and local governments should consider establishing fines for contractors working without a permit.

Utilities also have a role to play in providing the correct signal to the industry and to customers. Utility efficiency programs should not provide contractors or customers with a rebate for more energy-efficient cooling systems unless proof is provided that a permit has been obtained and quality has been verified and the permit made final. Sacramento Municipal Utility District has run a very successful air-conditioning program that does not make an incentive payment until proof of quality certification for each system is provided. Utilities should consider and develop programs to

increase the level of compliance with the quality requirements of Title 24, thereby increasing the anticipated peak and energy savings achieved by installation of new central air-conditioning systems. For example, utilities may want to help fund efforts by local building departments to either update their computer permitting systems, allowing permits to be downloaded on-line and to possibly increase their staff to provide support for the new systems.

Increase the Number of HVAC Contractor Technicians and Sales Representatives Who Take Training Courses and Meet New Certification Requirements Consistent with the Proposed Definition of High Quality and Labeling Requirements

Enhanced education and training of the HVAC industry contractors, building inspectors, technicians, installers, sales representatives, and third-party verifiers is required to improve the installation quality that is necessary to achieve energy efficiency from new central air-conditioning systems. Certification of a quality installation depends on training with clearly defined levels of knowledge, skills, and abilities.

Training will increase the number of industry-sanctioned HVAC technicians and installers. Trade associations must work with contractors to make certain they are willing to pay for employee training. The working group members envisioned expanding the number of examinations provided and administered by the Air Conditioning and Refrigeration Institute (ARI) (now known as the Air Conditioning, Heating, and Refrigeration Institute – or AHRI) and North American Technician Excellence.

More and better training could be accomplished through a combination of increasing support to certify new trainers and courses and providing utility incentives directly to technicians who complete training. This support should be designed to achieve a long-term training goal of ensuring 100 percent of all technicians have achieved the Industry Competency Standard or North American Training Excellence Certification (after four years of experience) by 2020. It will be difficult, if not impossible, to convince owners of HVAC firms to expand their training budgets without a stronger customer demand for quality installations and stringent contractor licensing requirements.

National organizations such as North American Technician Excellence report that a only small percentage of existing technicians and installers have completed industry sanctioned certification. A preliminary study of utility bills by North American Technician Excellence shows that systems installed by certified technicians achieve 10 percent better field-adjusted energy efficiency (with error band of +/- 5 percent) than work completed by individuals without certification.

A shortage of such qualified individuals in “green collar” jobs will only get worse as the “baby boom” generation approaches retirement. The U.S. Bureau of Labor Statistics estimates that the number of jobs in the HVAC (and refrigeration) industries will grow by 29 percent between now and 2014. In addition, the industry needs an estimated 27,000 new skilled workers annually to replace technicians who retire. Overall, this means that the industry requires a total of 35,000 new technicians a year. Contractors in the working group reported that there are between 20,000 to 50,000 technicians working in the state and that only a small fraction of these technicians are North

American Technician Excellence certified. Approximately 135 new technicians receive North American Technician Excellence certification each year.

The license process for contractors was described by the working group as another issue. California HVAC contractor licensing is conducted at the "company" level, not at the individual technician or installer level. Therefore, the person controlling the quality of installation is often not likely to be trained, certified, or aware of the critical need to get installation details right. Field adjusted energy efficiencies can either approach manufacturer ratings with "quality installations" or be diminished by as much as 50 percent with typical efficiency deficits of 30 percent due to poor quality installation.

Recommended Actions

The Energy Commission and utilities should support new and existing training programs of all kinds that prepare installers and technicians for certification using the Industry Competency Exams exam for entry level technicians or the North American Technician Excellence exam after five years of experience. The ultimate goal should be to certify 100 percent of all practicing HVAC technicians by 2020, using Industry Competency Exams for entry-level or with North American Technician Excellence certification for technicians with more than five years of service.

To support expanded training opportunities, it will be important to develop and/or recognize "train the trainer" programs that provide quality instructor training to bona fide HVAC quality installation and maintenance training programs. New training courses will need to be developed to enable sales representatives to sell HVAC systems based on overall system performance rather than the singular Seasonal Energy Efficiency Rating (also known as SEER). Training must be a continuous process rather than a once in a lifetime certification. Community colleges are an important venue for training and we should do what we can to bolster HVAC vocational education programs at their campuses. We should encourage all affected stakeholders to provide funding for increase training and certification.

Obtain a Commitment from Local Governments, State Agencies, Utilities, and Local Building Departments to Devote More Resources to Customer Education, Building Energy Inspections, and Streamlining the Permitting Process

Local governments have a history of developing innovative energy efficiency programs. Many cities in California have taken the initiative to develop sustainable development policies to reduce their energy and carbon footprint. This represents an opportunity to pursue cooperative policy goals. Utilities and the state's energy agencies should approach these officials and discuss whether they are interested in participating in the campaign to increase quality installation practices in new and existing homes with central air conditioning systems.

Recommended Action

California's energy agencies, utilities and other stakeholders should form partnerships with local governments interested in developing green or sustainable energy policies to help improve their

building department's ability to verify quality installation of HVAC systems and thereby reduce their energy usage.

Seek Regulatory Policy Changes

The energy agencies in California can modify policy directions to encourage utilities to achieve larger scale market outcomes. One area noted by the working group was to re-assess and possibly change the estimate of energy savings achieved by HVAC education, training, and enforcement efforts. Policy changes in the current planning and evaluation system could allow utilities to get credit for the energy and peak savings associated with training and education efforts.

Recommended Action

The California Public Utilities Commission should require that utilities conduct an evaluation of the market effects and resulting energy savings per household caused by branding, education, and training programs designed to increase compliance with the HVAC quality control provisions of the Energy Commission building standards. Utilities should work with the California Public Utilities Commission Energy Division staff to develop ex ante estimates of the energy and peak savings provided by increasing the level of compliance in these markets as a function of house size and HVAC system capacity. This will require the utilities to track changes in the fraction of quality installations that occur in this market and the energy and peak savings per installation.

CHAPTER 5:

Strategies to Increase the Efficiency of New Space Conditioning Systems Installed in California Over the Next Decade

The average efficiency of units sold in California has been trending up from 10.3 SEER in 1999 to 11.2 SEER in 2005.[3] Recent federal standards increasing the minimum efficiency from 10 SEER to 13 SEER have in effect resulted in an immediate 23 percent increase in the rated efficiency for new equipment. However, there is still room for improvement. A significant reduction in peak usage can be achieved by developing higher efficiency HVAC systems and making sure they are properly installed and maintained over their system life. This chapter will discuss several strategies to address increasing the efficiency of space conditioning systems.

Support Commercialization of On-Board and Portable Diagnostic and Fault Detection Systems

In 2006, a technology roundtable was convened in Oakland to discuss critical HVAC technical and research issues. The group issued a list of 10 consensus recommendations to "improve the operating efficiency and field performance of air conditioning systems." Five of these recommendations addressed system diagnostics:

- Develop a minimum industry standard for onboard diagnostics functionality for all units.
- Create a specification for designated sensor mount locations for field testing.
- Prioritize in-field diagnostic approaches based on benefit-cost of the energy savings, cost to diagnose/repair, and the frequency of occurrence of faults.
- Benchmark existing diagnostic and repair protocols to gauge the consistency of the tools currently used in the field.
- Gather protocols and data and post them to a common place to allow researchers and practitioners to examine the quality of the data including sensor and instrument types, accuracies, measurement uncertainties, and testing methods.

Many HVAC original equipment manufacturers currently offer on-board diagnostic equipment that integrates with their higher end systems while others offer hand-held systems that work with all systems. However, none of these systems are widely used by customers and/or contractors. Supporting further commercialization of diagnostic systems that automatically collect data and alert customers and contractors when a fault or negative performance trend is detected by the system will result in energy benefits by ensuring that systems continually operate within design specifications. Such systems will provide customers with real-time performance and servicing information directly at the thermostat and provide contractors the ability to download fault

[3] Itron, Inc. *California Residential Efficiency Market Share Tracking*, August 2006, pp 3-10

detection and diagnostic information during a service visit. Such systems will also communicate with smart meters and receive pricing signals and/or integrate with utility demand response programs and can integrate with in-home automation and utility-smart grids.

Recommended Actions

The working group identified a number of actions needed to support the commercialization of on-board and portable diagnostic and fault detection systems. First is to conduct consumer market research to establish the requirements of diagnostic systems that can communicate with customers, owners, occupants, contractors, and utilities. In order to enhance customer and/or contractor demand for onboard or handheld diagnostic systems, a market needs to be created and product development costs need to be reduced to have private industry invest in such systems. The Energy Commission should sponsor research to determine the degree of performance degradation in unitary, packaged, and split systems and provide financial support through its Public Interest Energy Research program for development and testing of fault detection and diagnostic systems into their cooling equipment and benchmarking energy savings resulting from their use.

Stakeholders could partner with manufacturers to develop sensing and communications functionality in HVAC equipment that integrates with warranty and service agreements with customers. The Energy Commission could consider making the 2008 diagnostics requirements that appear in the performance compliance approach a prescriptive requirement for the 2011 Title 24 building energy efficiency standards, and consider providing compliance credits for the next generation of diagnostics that incorporate monitoring-based commissioning. Lastly, utilities should consider funding a program that will provide cash incentives to the first 100,000 central air-conditioning systems brought to the market with on-board diagnostics integrated into the cooling systems and or thermostat.

Develop New Efficiency Performance Metrics to Promote Development of Advanced Cooling Systems Optimized for the Hot Dry Climates of California

Current HVAC appliance performance testing is conducted to national standards. Standard ratings for the seasonal energy efficiency ratio (SEER) are conducted at a maximum temperature of 82 degrees Fahrenheit and treat dehumidification as equal to sensible cooling. In the hot dry climates of California, outside air temperatures over 95 degrees Fahrenheit with 35 percent relative humidity is common. The current standards provide inaccurate assessments of energy requirements during peak periods in California and the Southwest.

Peak energy use is further amplified by the natural tendency of designers and contractors to provide a larger capacity system than necessary, resulting in excessive and inefficient cycling of the compressor. Increased cycling of a direct expansion air conditioning system reduces overall efficiency through cycle start-up losses which occur until the cold liquid refrigerant returns to the evaporator coil. The results of over sizing single-speed units include increased electrical peak and, in some cases, increased energy consumption.

Recommended Actions

The state should investigate a new efficiency metric for residential and nonresidential direct expansion, air cooled air conditioning systems that appropriately rates performance in hot and dry California climate zones. Since air conditioning equipment is covered by federal appliance regulations, the Energy Commission should continue its efforts to influence federal rulemaking activities that could result in different and improved ratings. The state should encourage the federal government to explore modifications to equipment efficiency ratings as recommended by ACEEE.[4] The Energy Commission should solicit expert opinion, and conduct public workshops to discuss and propose a method for rating and reporting individual unit performance in hot dry California climate zones during periods of extreme high temperatures.

In addition, the state's energy agencies should review the California Public Utilities Commission's "Total Avoided Cost Model" and Energy Commission's Title 24's Time Dependent Valuation calculations to assess their applicability for use as a performance-based platform for market incentives.

Accelerate Market Penetration of New Cooling Equipment Technologies

Since equipment ratings for unitary equipment with capacities up to 240,000 Btu/h are done on a national level, manufacturers have no incentive to develop equipment that performs differently for California's hot and dry climate zones. For any significant energy reductions to be realized in California, equipment performance must be addressed by stimulating the commercialization of new equipment technologies that perform optimally in the Southwest region of the United States.

There is a need to develop an incubator system where new cooling technologies are introduced and quickly integrated into the market. There are known technologies that might be appropriate for California that differ from the typical system currently installed. There are alternatives and modifications to the standard direct expansion systems that are in various stages of commercial development. Table 1 provides an overview of some alternative electricity-powered cooling technologies with a qualitative assessment of their availability, peak and energy impacts, cost and market potential. The last two columns provide an assessment by the working group of their relative potential to save energy and demand based on each technology's potential market share and per-site savings potential.

[4] *Improving Central Air Conditioner Performance Ratings: A Review of Seasonal Energy Efficiency Ratings*, Harvey M. Sachs, American Council for an Energy-Efficient Economy, Hugh Henderson, CDH Energy, Don Shirey, III, Florida Solar Energy Center; Steven Nadel, American Council for an Energy-Efficient Economy, October 2007.

Table 1
Overview of Alternative Technologies to Traditional Vapor Compression Systems

	Near Term (2007-08)	Mid Term (2008-09)	Applicable Market Sector	Statewide Potential Savings (kW)	Statewide Potential Savings (kWh)
Thermal Energy Storage	X		Commercial Residential	Med.	Low
Indirect Evaporative Cooling	X		Commercial Residential	Low	Low
Two Stage Evaporative Cooling	X		Residential	Low	Low
Gas/Electric Hybrid Systems		X	Commercial Residential	Med.	Med.
Hot Dry DX	X		Commercial Residential	High	High
Water Cooled Vapor Compression	X		Commercial Residential	Med.	High
Ground Source Heat Pump	X		Commercial Residential	Low	Low
Advanced Roof Top Unit	X		Commercial Residential	Med.	Med.
Ductless DX	X		Commercial Residential	Low	Low
Residential Economizer with Night Ventilation Cooling (Night Breeze)	X		Commercial Residential	n/a	High
Radiant heating and cooling	X	X	Commercial	Low	Low
Advanced Direct Evaporative	X		Commercial Residential	Low	Low

Source: Energy experts who attended the Big Bold Energy Efficiency HVAC Strategy workshops conducted by the California Public Utilities Commission on June 6, 2007.[5]

There are also several promising gas-driven technologies that can substitute for traditional vapor compression systems. These include direct and indirect thermal absorption systems, gas engine-driven air conditioning, steam-turbine driven chillers, displacement ventilation, and humidity control.

Recommended Actions

There are several organizations tasked with identifying, researching, and managing emerging technology in use in California (investor-owned utilities, Energy Commission's Public Interest Energy Research Program, universities, and economic development organizations). These organizations should work together to expedite the development and introduction of new cooling equipment appropriate for the hot dry market. The use of creative financial incentives, design competitions, or innovation incubators could be expanded. These entities must explore methods of integrating air-conditioning equipment with solar (for example, solar-thermal driven systems),

[5] The experts included Dick Lord, Marshall Hunt, and Lance Alberlink, PG&E; Ed Vine, CIEE/LBNL; Tom Roberts, DRA; Mariann Long, Utilities Joint Services, Anaheim; Cathy Higgins, New Buildings Institute; Greg Rosenquist, LBNL-contract work for DOE; and Randall Higa, SCE.

"smart metering" (improved controls), and research into solar-thermal cooling systems (thermally activated systems such as desiccants or absorption systems). As these new technologies emerge into the market place, contractor/technician education and training support will be needed to ensure that the infrastructure exists to install and service new equipment per quality installation standards.

Create a Market Environment That Encourages Whole Building Design

In addition to the equipment technologies listed in Table 1, there are design issues with the entire cooling "system" that need to be addressed. This includes developing solutions for a "whole-building" approach that improves the thermal integrity of structures, addresses lighting and appliance loads, moves ducts and equipment off the roof and out of hot attics, or eliminates the need for ducts with radiant heating or cooling.

The building heat gain determines the size of the unit required to provide adequate space conditioning. By not considering the entire building as part of the HVAC system, only one part of the solution is addressed. If the size of the HVAC unit can be reduced and still provide the necessary occupant comfort, the peak load will be reduced proportionally. The goal is to support increased architect and mechanical engineer usage of the concept of designing the house as a system. This is expected to have a beneficial effect by reducing the overall heat gain and loss in a typical home environment that the HVAC system is designed to meet.

Recommended Actions

Energy agencies and utilities should address current cooling system design limitations by encouraging builders and contractors to adopt a "whole-building" design approach that improves the overall thermal integrity of new and existing structures. The Energy Commission can continue to explore code-based solutions to improving thermal structural integrity and moving duct systems and equipment from roofs and attics. The Commission can also consider how it can help to create a paradigm shift in current HVAC system design approaches by developing code-based solutions to incorporate ductless, radiant heating and cooling, and ground-source heat pumps into all new construction. Finally, supporting improved building and system designs through training and education of builders, contractors, installers, and building code officials is an area that the CPUC and all utilities can assist the Energy Commission in accomplishing.

APPENDIX A

Energy and Peak Consequences of the New Vision

This section estimates the level of energy and peak savings that could be achieved if:

1) A higher percentage of common central air conditioning systems achieve and verify the quality specifications for proper airflow, refrigerant charge, and maximum duct leakage.
2) A higher percentage of new air conditioning equipment with dramatically reduced peak requirements (thermal storage and other advanced cooling techniques) is installed in the medium to long term.

The information in this appendix was prepared by the working group. The estimated savings in energy and electricity peak demand demonstrate why efforts to improve the installation quality and increase use of alternative equipment are important to California.

These estimates are conservative in that they do not attempt to quantify the potential savings from increasing the efficiency of new hybrid systems with lower peak requirements. Rather these estimates only attempt to estimate the savings achieved by increasing the level of compliance of typical equipment with current code from 10 percent to 90 percent over a multi-year period. To accomplish this task, some reasonable estimates about the consequences or loss of energy savings in the current market are needed. The baseline for these estimates includes a high level of non-compliance with Title 24.

Increases in Quality Installation Practice

Table A-1 presents estimates of the fraction and absolute number of central air conditioning (CAC) installations that are not meeting the manufacturer's quality control specifications for airflow, refrigerant charge, and the Energy Commission's duct sealing requirements.

Table A-1
Estimated Annual Number of CAC Installations in Dwellings with Potential Energy Savings from Quality Control Improvements

Job Type	Fraction in Compliance with Bldg Code Requirement for 3rd party Quality Verification	Fraction of Installations Meeting Manufacturer and/or Building Code Quality Specifications *	Fraction of Installations with Significant Energy/Peak Savings Potential from Quality Installation Initiatives	Number of Installations of CAC Systems in Residential Dwellings with High Savings Potential in 2005
Replacement	10%	15%	85%	337,875
New Construction	30%	50%	50%	81,650

* Meeting Quality Specifications is defined as ensuring that airflow exceeds 350 cfm per ton, refrigerant charge is within the manufacturer's requirements, and duct leakage is less than 10% of conditioned air to the outside at 25 Pascals.

The compliance estimates in Column 2 are derived from interviews with building officials, HERS raters and a recent study of compliance rates in residential and nonresidential buildings[6].

In Column 3, the estimated proportion of quality replacement installations performed by technicians was increased to 15 percent to account for the likelihood that some technicians will perform quality installation checks or measurements on their own without pulling permits and without confirmation by third parties. In the new construction market, the authors assume that an additional 20 percent of the technicians perform the relevant quality checks on their own. This estimate is added to the 30 percent that are using building code third-party verifiers to check their work to yield an estimate that 50 percent of the central air conditioning systems are meeting quality control requirements in new construction.

The final column in Table A-1 shows the annual estimate of central air conditioner installations with significant potential for achieving energy and peak savings because of poor quality installations that have not been verified. The final column is simply the fraction of installations with significant savings potential (Column 4) multiplied by the estimated number of replacement and new construction central air conditioning systems in 2005 (397,500 replacement systems and 163,300 systems installed in new homes).[7]

Table A-2 shows the estimated energy and peak savings from increasing the fraction of installation jobs that meet the quality installation threshold from the baseline fractions of 10 and 15 percent respectively derived in Table A-1 to 90 percent on an annual basis. Savings per

[6] M. Sami Khawaja, Ph.D., Allen Lee, Ph.D., Michelle Levy, Quantec, LLC, *Statewide Codes and Standards Market Adoption and Noncompliance Rates* (Southern California Edison, May 10, 2007)
[7] Itron, Inc. *California Residential Efficiency Market Share Tracking*, August 2006, pp 3-4

household estimates were taken from the low end of the range estimated in the national EPA study[8]. Per-unit energy savings of 20 percent of baseline cooling energy usage for existing buildings and 15 percent for systems installed with quality practices and verification in new homes were assumed. A lower fraction of 15 percent for replacements and 10 percent for new homes were assumed for peak savings impacts. Baseline energy and coincident peak energy usage were taken from the Energy Commission's latest forecast of electricity use.

Table A-2
Potential Annual Energy and Peak Savings Resulting from Quality Installation Verification from Homes with Savings Potential in 2006

Residential HVAC Market	2006 CAC Installations with Savings Potential (from Table A-1)	Baseline Energy Use (a)	Baseline Coincident Peak Use (b)	Energy Savings/HH for CAC Installs with Quality Verification (c)	Estimated Peak Savings/HH for CAC with Quality Verification	Annual Energy Savings	Annual Peak Savings
Market Type	**CAC Systems**	**kWh/HH/yr**	**kW/HH**	**kWh/yr/HH**	**kW/yr/HH**	**MWH/yr**	**MW**
Replacement	346,322	2,080	2.50	416	0.37	147,584	130
New Construction	83,283	1,335	2.18	200	0.22	16,679	18

HH = Household

Notes:

(a) 30 percent multiplier applied to average unit energy consumption from Energy Commission 2007 forecast to adjust baseline usage for homes without third-party verification of quality specifications

(b) Peak demand converted to coincident demand by reducing connected load by 48 percent

(c) Energy saving per household estimated at 20 percent of baseline use for existing homes and 15 percent of baseline use for new construction households

(d) Peak savings per unit estimated at 15 percent of baseline for existing homes and 10 percent of peak usage for new construction

These calculations suggest annual peak and energy savings of 164 GWH and 148 peak MW in the residential sector are possible. This level of peak savings is comparable to the peak savings of 166 MW reported for Southern California Edison's program portfolio in 2006. The real uncertainty in these savings estimates is how long it will it take to achieve an increase in verified quality installations from the 10 to 15 percent observed today to the target of 90 percent quality certifications for all installations.

[8] Chris Neme, John Proctor, and Steve Nadel, *National Energy Savings Potential from Addressing HVAC Installation Problems*; (Prepared for the U.S. EPA, February 1999.)

Energy and Peak Savings from Increasing the Peak Efficiency of Future HVAC System Installation in the Residential Sector

Tables A-3 and A-4 illustrate the potential peak savings that could be achieved over the next twelve years under two different scenarios:

1) The rapid market penetration of advanced cooling systems with the capability of reducing peak demand by 20 percent beyond the levels achieved with 13.0 SEER equipment. In this scenario the market share of these new more energy-efficient systems is assumed to increase from 1 percent to 50 percent by 2020.

2) The rapid market penetration of thermal storage systems with the capability to shift more than 90 percent of peak requirements to off-peak periods. In this scenario the market share of these new thermal storage systems is assumed to increase from less than 1 percent currently to 25 percent by 2020.

Table A-3
Potential Peak Savings from Accelerated Penetration of More Efficient HVAC Systems in Residential Markets

Year	Fraction of Market with High Efficiency Cooling Systems	Cumulative Energy Savings GWH	Cumulative Peak Savings MW
2008	1%	2	3
2009	5%	14	18
2010	10%	37	48
2011	13%	68	87
2012	16%	108	138
2013	20%	158	202
2014	25%	221	283
2015	30%	299	382
2016	33%	387	564
2017	37%	489	696
2018	42%	604	857
2019	47%	736	1,050
2020	50%	879	1,272

Sources: The energy and peak savings per household estimates for Table A-3, more efficient conventional HVAC systems, use the same baseline energy and coincident peak usage per household assumed shown in Table A-2. These baseline usage estimates are then reduced by 20 percent to simulate the impacts of installing high efficiency cooling systems. Peak savings at the statewide level are estimated at 49 kW per household for HVAC replacements and 44 kW for new construction. The market share estimates in Column 2 are based on an estimate of the cumulative effects of an aggressive promotion of high efficiency HVAC systems.

Table A-4
Potential Peak Savings from Accelerated Penetration of Thermal Storage CAC Systems in Residential and Small Commercial Markets

Year	Fraction of Market with Thermal Storage Technology	Cumulative Peak Savings MW
2008	0.5%	11
2009	1.5%	43
2010	2.5%	97
2011	3.1%	163
2012	3.7%	243
2013	4.5%	341
2014	5.5%	461
2015	6.8%	607
2016	8.2%	785
2017	11.0%	1021
2018	14.6%	1336
2019	19.4%	1755
2020	25.2%	2299

Sources: The cumulative peak savings include both coincident and non-coincident peak savings, accumulated for each year based on the fraction of market share achieved in that year (includes the savings for all accumulated thermal storage systems installed through that year). The coincident peak savings estimates for the thermal storage systems are based on data from the Energy Commission's approved data charts used for estimating the non-coincident peak demand attributable to Ice Storage Air Conditioners in an Energy Commission program to install these systems in Victorville, California. The charts are titled *CALIFORNIA ENERGY COMMISSION APPROVED METHODOLOGY FOR ESTIMATION OF PER UNIT PEAK LOAD SAVINGS, ADJUSTED FOR EQUIPMENT SIZE, AGE, AND LOCATION, INDOOR FAN AND PUMP POWER CONSUMPTION, UTILIZING D.O.E AND C.E.C. RECOGNIZED VALUES.* Documentation of the assumptions used to estimate these peak shift values can be found in the Energy Commission staff publication *Ice Storage Application: Compliance Options Application* which can be found at: *http://www.energy.ca.gov/2006publications/CEC-400-2006-006/CEC-400-2006-006-SF.PDF* . The non-coincident peak savings estimate is multiplied by 0.52 to convert it to coincident peak savings. Peak savings per household ranges from 1.77 kW (3 ton unit) to 3.23 kW (4 ton unit). The market share estimates for thermal storage technology is simply a hypothesis of what could happen under an aggressive market promotion program.

Efforts to increase the efficiency of new HVAC systems could potentially yield large peak savings, perhaps 1,000 to 2,000 MW in the long run. The thermal storage scenario (Table A-4) yields higher total peak savings primarily because of the larger potential peak savings per household of roughly 2 kW per household relative to the 0.49 kW per household assumed for the more energy efficient HVAC system scenario shown in Table A-3.

Small Commercial Savings Potential

Table A-5 shows the Energy Commission forecast estimates of cooling energy use for the building types that can be characterized as small commercial. These buildings use the same equipment as homes. A gross estimate of potential energy and peak savings can be obtained by assuming peak and energy savings that could be achieved in the small commercial sector are comparable to the proportions estimated in the residential case. In the residential case, the potential peak and energy savings from increased quality installations were estimated at 2.3 percent of 2007 peak usage and 3.7 percent of 2007 energy usage. If these fractions of usage to savings are similar for small commercial buildings, the potential energy savings will be 133 GWH/year, and the potential peak savings will be 70 MW/year.

Table A-5
2007 Cooling Peak Demand by Building Type (MW)

	Utility Service Areas								Statewide
Building Types in Small Commercial Market	**BUGL**	**PASD**	**IID**	**LADWP**	**PGE**	**SCE**	**SDGE**	**SMUD**	**Total Non-Coincident Peak MW***
Small Office	8	5	52	57	204	222	126	66	740
Restaurant	3	2	8	32	32	121	21	4	223
Retail	19	10	49	131	224	554	113	51	1,151
Food Stores	2	1	6	8	258	42	12	21	350
Refr Warehouse	0	0	0	0	0	1	0	0	1
Schools	4	2	49	32	9	167	37	1	301
Hotel/Motel	1	1	7	40	24	160	54	4	291
	37	21	171	300	751	1,267	363	147	3,057

*Totals are non-coincident since the utility peaks occur at different dates and hours.
BUGL = Burbank/Glendale
PASD = Pasadena
IID = Imperial Irrigation District
LADWP = Los Angeles Department of Water and Power
PGE = Pacific Gas and Electric
SCE = Southern California Edison
SMUD = Sacramento Municipal Utility District

Energy and Peak Consequences of Implementing New HVAC Technologies and Simultaneously Reducing Building Loads Through Whole Building Design

Table A-6 illustrates the potential savings from existing and future cooling technologies that reduce peak usage while simultaneously addressing the requirements of the whole building by integrating design improvements to the building shell.

Table A-6
Estimated Potential Energy Savings from New and Improved Space Conditioning Technologies and Improvements to the Design of the Shell Using a Whole Building Approach to New and Existing Buildings

Job Type	Potential Reductions from Air Conditioning Systems Designed, Selected, or Retrofitted for their Performance at Hot Dry Peak Conditions	Potential Reductions from a Comprehensive Whole Building System to Reduce Energy Consumption Through Cost-Effective Means	Potential Reductions from a Metric That Incorporates Performance at Hot Dry Peak Conditions
Retrofit	15% to 25%	15% to 30%	
Replacement	15% to 45% (up to 90% peak reduction)	15% to 60%	15% to 25%
New Construction	15% to 25% (up to 90% peak reduction)	50% to 90%	15% to 25%

Summary of Potential Energy and Peak Savings

Table A-7 presents the estimated potential energy and peak savings for the major identified strategies increased quality control, the accelerated adoption of more efficient cooling technologies, and new peak-shifting cooling technologies. This table assumes the peak savings achieved in the small commercial market will be proportional to the relationship between residential peak demand and small commercial peak demand. Based on this relationship, estimated peak and energy savings from the small commercial market are 21 percent of the estimated savings from the residential market.

Table A-7
Potential Energy and Peak Savings from High Level Strategies

	Cumulative Savings from Quality Verification in Residential and Small Commercial Markets	Cumulative Savings from Quality Verification in Residential and Small Commercial Markets	Cumulative Savings from Accelerated Introduction of New More Efficient Cooling Technologies	Cumulative Savings from Accelerated Introduction of New Peak Shifting Cooling Technologies
Year	Energy GWH	Peak MW	Peak MW	Peak MW
2008	24	18	3	11
2009	84	73	18	43
2010	204	182	48	97
2011	363	325	87	163
2012	562	505	138	243
2013	770	693	202	341
2014	991	893	283	461
2015	1,216	1,096	382	607
2016	1,216	1,096	564	785
2017	1,216	1,096	696	1021
2018	1,216	1,096	857	1,336
2019	1,216	1,096	1,050	1,755
2020	1,216	1,096	1,272	2,299

In the first five to ten years, the savings from the quality verification program are larger than the potential savings from the accelerated technology programs. However, the cumulative savings from the two accelerated technology scenarios exceed the peak savings from the quality verification program in 2016 and get much larger by 2020. This suggests that a balanced portfolio approach for the HVAC sector would fund the quality initiatives to achieve near term savings and the programs to accelerate the introduction of innovative technologies to achieve higher savings in the mid to long term.

Glossary

ACCA	Air Conditioning Contractors of America
ACEEE	American Council for an Energy Efficient Economy
ARI	Air conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
Btu (and Btu/h)	British thermal unit (and British thermal unit per hour)
CALBO	California Building Officials
CAC	Central Air Conditioning
Energy Commission	California Energy Commission
CIEE	California Institute for the Energy and Environment
CMC	California Mechanical Code
CPUC	California Public Utility Commission
CSLB	California State Licensing Board
DOE	Department of Energy (federal)
DRA	Division of Ratepayers Advocate
EPA	Environmental Protection Agency
EER	Energy Efficiency Ratio
ETCC	Emerging Technology Coordinating Council
HERS	Home Energy Rating Specialist
HVAC	Heating Ventilation and Cooling
ICE	Industry Competency Standard
IHACI	Institute of Heating and Air-Conditioning Industries, Inc.
IOU	Investor owned utility
LBNL	Lawrence Berkeley National Laboratory
NATE	North American Technician Excellence
OEM	Original Equipment Manufacturer
PAHRA	Partnership for Air Conditioning, Heating, and Refrigeration Accreditation
PIER	Public Interest Energy Research
PG&E	Pacific Gas and Electric
QI/QM	Quality Installation/Quality Maintenance
RSES	Refrigeration Service Engineering Society
SCE	Southern California Edison

SDG&E	San Diego Gas and Electric
SEER	Seasonal Energy Efficiency Ratio
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SCG	Southern California Gas Company